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(54) A method and an apparatus for sorting solids.

(57) A method and an apparatus for sorting particulate solids material. The material is subjected to a microwave field and absorbs energy to an extent depending upon the dielectric properties of the individual particles. The absorbed energy heats the particles and pyrodetectors detect the heat radiation. Detector output signals control pressurized air jets deflecting particles detected to be colder than the remainder of the bulk.

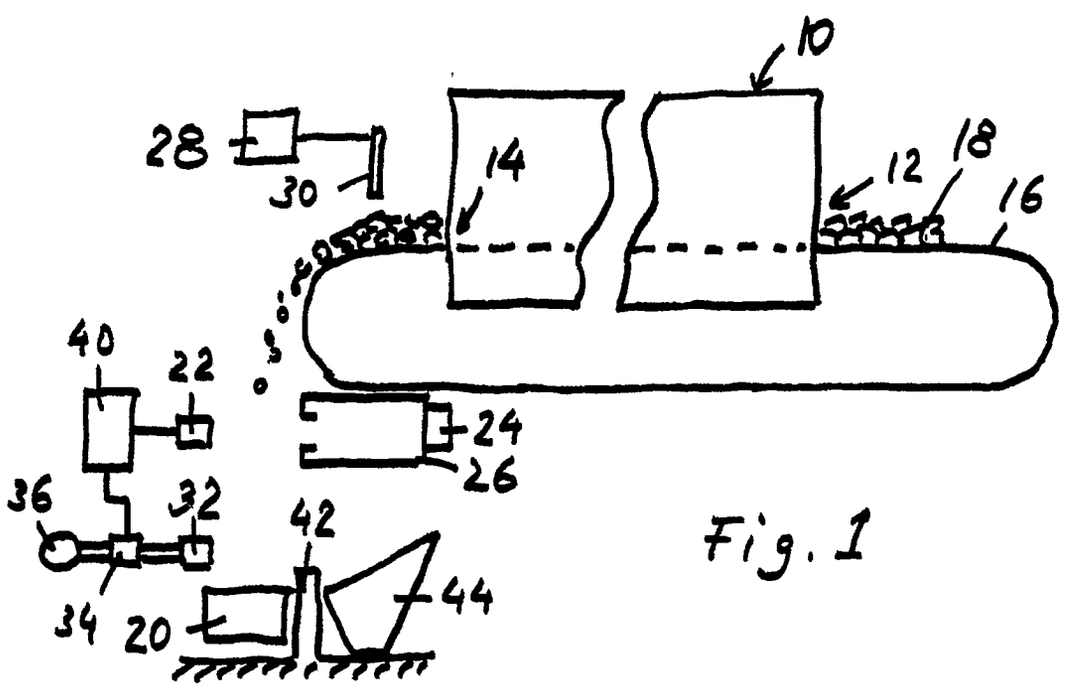

Fig. 1

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The present invention relates generally to recycling methods and apparatus, and in particular to a method and an apparatus for sorting particulate solid mixtures.

It would be easy to recycle waste if such waste would consist of only one material or one material class, as metals. Therefore, attempts are made to collect particular types of waste separately, as glass, metal, paper etc. However, most of the waste comprises a mixture of many different ingredients. Moreover, even if waste of a particular material is separately collected, one cannot be sure that in fact it will not contain others. For example, if glass bottles are collected, quite frequently one will find metallic closure caps, too, in the containers so that sorting is indispensible.

It is the object of the present invention to provide a method for sorting particulate mixtures of solids and to provide an apparatus for implementing the method.

According to the invention, the method for sorting solids in response to their electric conductivity comprises the steps of: Subjecting the solids to a microwave field of predetermined power and frequency over a predetermined time interval whereby the solids assume different temperatures depending upon their dielectric properties, detecting the temperatures, and classifying the solids in response to the detected temperatures.

According to the invention, an apparatus for sorting solids in response to their electric conductivity comprises a microwave furnace, means for conveying the solids through the furnace whereby the solids assume temperatures depending upon their dielectric properties, means for detecting the temperatures, and means for classifying the solids in response to detected temperatures.

The method of the invention is based on the consideration that each substance has an electric conductivity or dielectric properties which are characteristic for the particular material. However, the electric resistance of an item does not only depend upon such conductivity but also upon the size and shape thereof so that sorting based on direct measurement of the electric resistance of each particle seems impossible. The invention therefore provides that, firstly, the bulk of particles is subjected to a microwave field where each particle absorbs energy in accordance with its dielectric properties, and the absorbed energy raises the temperature of the particles in accordance therewith. In a second step, the temperatures of the particles is detected, preferably without physical contact, the the particles are classified in response to the detected temperature.

German published patent application DE-31 13 736-A1 describes a method to locate reinforcement bars in concrete walls wherein the wall is subjected to a RF field so as to create inductive heating in the steel, and temperature differences are detected so as to assess the site where steel reinforcment bars may be found.

German published patent application DE-38 34 574-A1 discloses a method for microwave heating of different products contained in closed packings wherein the microwave power is varied in response to the temperature of each product when it enters a microwave chamber. Of course, in order to properly adjust the power, the material or at least its dielectric properties must be known beforehand.

A detector particularly suited to detect heat radiation from a microwave-heated item is one which responds to radiation transitions; such a detector is disclosed in German Patent Specification DE-35 08 253-B1.

A preferred embodiment of an apparatus for implementing the method of the invention will be described in detail hereunder with reference to the attached drawings.

Fig. 1 illustrates the apparatus schematically in a side view, and

Fig. 2 is a partial top view of the apparatus.

The apparatus or installation is provided to clean rotten or composted household and garden waste from impurities as glass, ceramic, plastics, metals and the like. It will be understood that other similar sorting or classification processes may be implemented, as e.g. the sorting of a mixture of plastics material articles as bottles or containers. It is known that the dielectric properties of materials even if under normal conditions they are considered to be all "isolators" are quite different depending upon the composition of such material, and that those properties also vary somewhat with the microwave frequency. Accordingly, depending upon the sorting criterion the microwave frequency, microwave power and the duration of the irradiation interval will be varied. Further, it will be understood that sorting may be implemented in a plurality of cycles. For example, at first metals are discriminated against the remainder of the mixture by means of the method of the invention. Second, organic materials are discriminated against inorganic ones using again the method of the invention; in the successive cycles, one will adapt the frequency and power as well as the irradiation interval to the particular discrimination criterion.

The apparatus comprises a microwave furnace 10 having an inlet 12 and an outlet 14. A belt conveyor 16 is loaded with to-be-cleaned compost 18 and conveys it through the furnace. Such furnaces including conveyor means are readily available.

The irradiated material passes through the furnace outlet and falls freely unto a collector 20 which may also be a belt conveyor. Assuming that

metals have been removed already in a first cycle, the compost has been heated by the absorbed microwave energy while the "isolators" have absorbed very little energy and remain substantially at the temperature they had prior to passage of the microwave field. However, due to heat conduction those items may rapidly assume the temperature of their environment. Accordingly, the microwave power and the passage time are adjusted such that beyond the outlet, their has not yet occurred much heat transfer.

The falling material passes through a gap between a bank of pyrodetectors 22 and an artificial background opposite the pyrodetectors. This background consists of a radiating black body in the form of a box having an open front facing the pyrodetectors and heated to approach the temperature of the compost particles. For this purpose, a heater 24 is mounted on the exterior of the rear wall 26 of the box, and the heater is controlled by a control unit 28 in response to an input signal representative of the compost temperature measured by means of a thermometer 30.

The pyrodetectors therefore "see" a substantially constant temperature as long as there is no output from the microwave furnace or output of clean compost. However, if a (relatively) cold object falls across the detector bank, one or a plurality of the detectors will respond to the radiation transition attributable to such cold item. It has been found that a bank of detectors spaced about ten millimeter from oneanother is very suited to clean the compost sufficiently.

A transition hot/cold produces a positive going spike, and a transition cold/hot produces a negative going spike. Beneath the bank of detectors is a bank of nozzles 32, each nozzle being connected via a solenoid valve 34 to a manifold 36 supplied with pressurized air. Each individual solenoid is controlled by the output signals of the particular detector mounted above the nozzle to which this solenoid is allocated. A control unit 40 processes the detector output signals so as to amplify them and to delay them in accordance with the time a detected object will need to fall from the detector level to the nozzle level. Accordingly, the valves are opened upon a hot/cold transition and closed upon a cold/hot transition. The air jet is directed such that a cold object is deviated beyond a partition wall 42 separating the compost collector 20 from a "non-compost" collector 44.

It will be appreciated that modifications of the method as well as of the apparatus may be provided. For example, if the compost is wetted before it is fed through the microwave furnace, the organic material will absorb much more energy than the inorganic so as to facilitate discrimination. Further, instead of the belt conveyor which extends through the microwave furnace, the bulk of solids to be classified could be fed to the furnace inlet and than made freely fall therethrough; this may be suitable where different types of "isolators" are to be sorted. The air jet nozzles could be replaced with mechanical means. Therefore, it is intended that the scope of the invention is defined by the appended claims.

Claims

1. A method for sorting solids in response to their electric conductivity, the method comprising the steps of:
   - subjecting said solids to a microwave field of predetermined power and frequency over a predetermined time interval whereby said solids assume different temperatures depending upon their dielectric properties,
   - detecting said temperatures, and
   - classifying said solids in response to said detected temperatures.

2. The method of claim 1 wherein a stream of solids is passed through a microwave furnace and thereafter falls freely through a detection and classification area.

3. The method of claim 1 wherein said solids comprise organic material, as household and garden waste, and inorganic material, as glass, ceramic and plastic material, and wherein said microwave power and frequency and said time interval are selected to heat said organic material to a detectably higher temperature than said inorganic material.

4. The method of claim 3 wherein said solids are wetted prior to being subjected to said microwave field.

5. An apparatus for sorting solids in response to their electric conductivity, comprising:
   - a microwave furnace,
   - means for conveying said solids through said furnace whereby said solids assume temperatures depending upon their dielectric properties,
   - means for detecting said temperatures, and
   - means for classifying said solids in response to detected temperatures.

6. The apparatus of claim 5 wherein said conveying means include a belt conveyor.

7. The apparatus of claim 5 wherein said detector

means include at least one detector responsive to heat radiation.

8. The apparatus of claim 7 wherein said detector is a pyrodetector.

9. The apparatus of claim 5 wherein said classifying means include controlled nozzles directing a jet of pressurized air against selected solid particles.

10. The apparatus of claim 5 wherein said conveying means are adapted to drop heated solids so as to make them fall freely across a bank of detectors and thereafter across a bank of air jet nozzles and wherein each nozzle is switched on and off by signals produced by an allocated superposed detector.

11. The apparatus of claim 5 wherein said detector means include detectors responsive to temperature transitions.

12. The apparatus of claim 9 wherein a background radiation generator is disposed opposite said first bank, said solids falling between said bank of detectors and said generator, and said background radiation generator producing a background radiation simulating heat radiation of solids having a relatively high electric conductivity, and said detectors being adapted to discriminate solids having a relatively low electric conductivity against said background radiation.

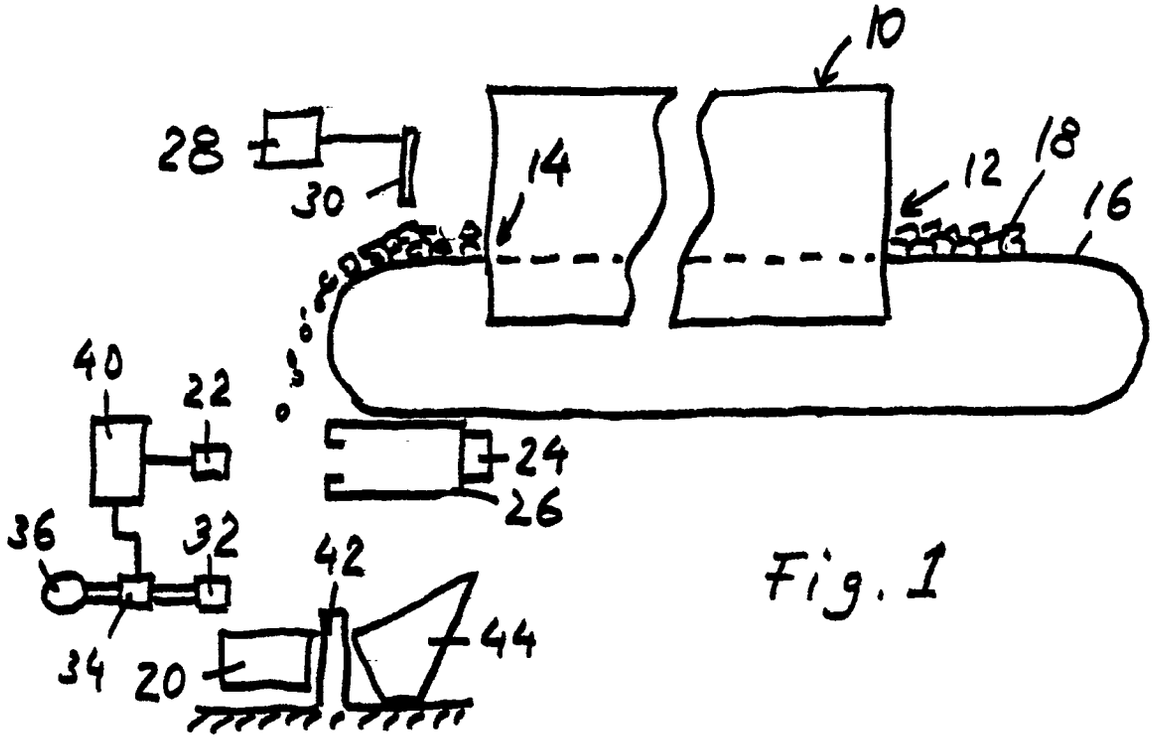

Fig. 1

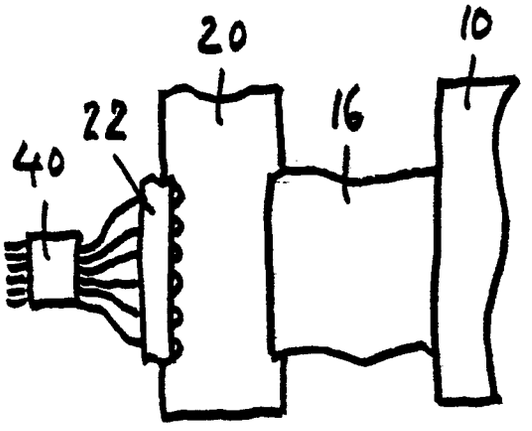

Fig. 2